Workload intensity and rest periods in professional ballet: Connotations for injury

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ABSTRACT

Fatigue and overwork have been cited as the main cause of injury with the dance profession. Previous research has shown a difference in workload between professional dancers of different rank, but the role of sex has not been examined. The purpose of this study was to determine workload intensity, rest, and sleep profiles of professional ballet dancers. 48 professional ballet dancers (M=25, F=23) took part in an observational design over 7-14 days using triaxial accelerometer devices. Minutes in METS at different intensities, total time asleep and rest breaks were analysed. Significant main effects for rank ($p<0.001$) and rank by sex ($p=0.003$) for total PA, working day activity, post work activity and sleep. Sleep ranged between 2.4-9.6 hours per night. All participants spent more time between 1.5-3 METS outside of work. Significant amounts of exercise where carried out outside of their work day, therefore when injury is reported per 1000 hours dance activity, this extra-curricular activity might need to be included. When looking at potential causes of injury in dance, a global perspective of physical activity is required that includes activity outside of work and sleep patterns, all activities that influence physiological recovery.

Key Words: triaxial accelerometry; dance; dancer; sleep; rest breaks; male vs female; ranks within professional company

INTRODUCTION

Fatigue and overwork have been cited as the main self-reported causes of injury within dance[1]. While the causes of injury are multifactorial, injuries appear to be more common when a dancer is fatigued[2, 3] and many injuries are related to overuse and insufficient recovery[4]. There has been little research into the physical demands of dance, let alone the daily global and work exposures of professional dancers. A typical schedule for a dancer employed by a full-time ballet company consists of a morning technique class of 1-2 hours in length, followed by several hours of rehearsal. During performance periods, the day will culminate with an evening show. Significant differences have been noted amongst intensity levels of dance class, rehearsal, and performance[5, 6], with improvements in maximal oxygen uptake only seen following an extended performance period[7]. Rodrigues-Krause et al determined mean VO_2 values during ballet class reached 39% of maximum, while average rehearsal values were 52% of maximum[8].

In contrast to indirect calorimetry – which is too bulky for everyday use – accelerometry provides a portable and unencumbering method to estimate workload intensity and energy expenditure and has been validated in a number of general- and athletic-population studies[9-13]. It has been used to determine workload intensity and sleep in ballet[14, 15] and Latin American dancers [16]. Twitchett et al[17] reported on daily work intensities (METS) of professional female ballet dancers and noted differences between the ranks for percentage time spent at different work intensities. Soloists had the greatest mean daily MET demand; all ranks, with the exception of the soloists, spent more time below 3 METS than above it. Time spent above 9 METS accounted for less than 5% of the day for all the ranks, though principals and soloists spent more time above 6 METS than first artists and artists. Allen et al[3], from a different company, recorded 4.4 time-loss injuries per 1000 hours of exposure to dance activities, with soloists and first artists having the highest injury incidence (4.18 and 5.26 injuries per 1000hrs).

Recovery, particularly in the form of sleep, may impact feelings of fatigue and a dancer's ability to recover from strenuous work. Fatigue is often cited as a factor in injury risk, but the sleep patterns and needs of elite athletes are still poorly understood. Leeder and colleagues[18] found Olympic-caliber athletes demonstrated decreased sleep quality when compared with matched controls, and the male athletes demonstrated poorer sleep efficiency compared to females. In spite of this, it has been theorized that athletes may require more sleep than non-athletes to combat the immunosuppressive effects of exercise[19]. The amount of sleep necessary appears to be highly individual, with normal ranges reported between 5-10 hours per night[19]. Very little previous research has investigated sleep in dancers, but Fietze and colleagues found total sleep and sleep efficiency in professional ballet dancers declined significantly over two months of rehearsal as a premier approached[20]; cognitive and health markers were similarly reduced. Given these results, there is a need for additional information regarding the sleeping habits of dancers.

The purpose of this investigation was to determine the workload intensity and quantity of rest across a 24-hour period in professional ballet dancers grouped by company rank and sex. Two research questions were examined: firstly, is there a difference in sleep and physical activity time (>1.5 METS) for total day, work day and outside of work activities between dancers of different rank and/or sex? Secondly, is there a difference in time spent at different work intensities during the work day and outside of work activities between rank and/or sex?

MATERIALS & METHODS

This study was undertaken to describe the daily workload and rest profiles of professional ballet dancers, and to determine whether differences existed based upon the rank and/or sex designation of the dancer. Dancers from two full-time professional ballet companies wore a triaxial-accelerometer armband (SenseWear 5.2, Bodymedia, Inc., Pittsburgh, PA, USA) for a period of one week, and each individual day was analyzed to ensure an accurate representation of a typical day of work. Ethical approval was granted by the corresponding author's institutional ethics committee.

Participants

Participants for this study were recruited from two full-time contracted ballet companies in the United Kingdom based in different cities. The companies had a total of 128 dancers between them; 15 dancers (5 Principals, 2 Soloists, 3 First Artists and 6 Artists) were ineligible to participate because of injury preventing full participation in training[3] resulting in a total pool of 113 dancers. These included 15 Principal dancers (M=7, F=8), 25 Soloists (M=9, F=16), 25 First Artists (M=12, F=13) and 47 Artists (M=27, F=20). Forty-two percent of the dancers eligible to participate volunteered; they comprised of 25 males (45%) and 23 females (40%); the four ranking categories were represented: Principal dancers (46%); Soloists (64%); First Artists (52%; and Artists (32%) (Table 1). Data were collected from a total of 48 dancers continuously across one or two week non-performance periods.

Table 1. Mean participant anthropometric data

Rank	Sex	Age (years)	Height (cm)	Mass (kg)	BMI	Smoker (#)
Principal	Male (n=3)	28.7 ± 4.04	177.0 ± 1.73	70.6 ± 0.67	22.5 ± 0.24	0
	Female (n=4)	30.8 ± 4.27	161.5 ± 1.73	47.3 ± 3.29	18.2 ± 1.65	0
Soloist	Male (n=4)	29.3 ± 6.24	179.8 ± 2.36	75.1 ± 5.34	23.3 ± 2.03	1
	Female (n=9)	28.4 ± 4.77	164.0 ± 4.36	50.9 ± 4.48	18.9 ± 1.43	0
First Artist	Male (n=9)	25.4 ± 3.84	178.3 ± 4.87	71.3 ± 6.14	22.4 ± 0.96	1
	Female (n=4)	27.3 ± 3.78	161.3 ± 4.79	45.4 ± 6.33	17.4 ± 1.49	1
Artist	Male (n=9)	22.8 ± 2.82	176.8 ± 3.35	68.3 ± 5.48	21.6 ± 1.30	3
	Female (n=6)	22.8 ± 1.17	165.1 ± 1.60	51.7 ± 3.80	18.9 ± 1.12	0

Procedures

Each participant was instructed to wear a SenseWear 5.2 triaxial accelerometer armband (Bodymedia, Inc., Pittsburgh, PA, USA) on the right upper arm for seven consecutive days, removing the device only to bathe. Participants from one company (n = 27) repeated the 7-day measurement 3 weeks following the initial collection.

Using a combination of two accelerometers and sensors monitoring galvanic skin response, heat-flux, and skin- and near-body ambient temperature, the SenseWear 5.2 armband estimates energy expenditure in kilocalories and exercise intensity in metabolic equivalents (METS). The accuracy of estimations using this device has been established previously [9, 12, 13, 21-23]. We carried out a validity test on three dancers using a portable gas analyzer (Cortex 3b ultra, Cosmed, Germany) and wearing the armbands during a truncated 30-minute dance class that included barre, center, adagio and allegro sections. Linear regression indicated a strong relationship between 1-12 METS ($r=0.89$, $p<0.05$ SEE ± 0.23). Above 12 METS the relationship drifted with the Sensewear armbands over reporting METS by 5-8%.

Dependent variables included exercise intensity as expressed in minutes spent in each of four intensity bands: low (1.5-3 METS); moderate (3-6 METS); vigorous (6-9 METS); and very vigorous (>9 METS); these were recorded for the full 24-hour day and its components of work day (WD-PA - defined as Monday-Friday, 10:00 am – 6:00 pm) and extra activities (Extra-PA – outside Monday-Friday, 10:00 am – 6:00 pm). Rest breaks during the working day were determined by calculating the greatest number of consecutive minutes spent at METS < 1.5 (Greatest Rest Break, or GRB), other breaks (MRB), and the total accumulated rest (GRB+MRB). Finally, the total hours of sleep per 24 hours were recorded.

Data analysis

Each 24-hour time period representing days on which participants were contracted to work (Monday – Friday, 8:00 am – 7:59 am) was analyzed as a single day. Any day where the armband was removed for more than 60 consecutive minutes was discarded. There was a potential total of 375 collection days though 103 days (27.5%) had to be discarded due to incomplete data (27 days) and exclusion due to injury (76 days), yielding 272 individual days. To determine the workload from dance activities, working hours (10:00 am – 6:00 pm) were analyzed separately.

Statistical Analyses

Differences in METS bands (WD-PA and Extra-PA), rest variables (GRB, MRB), and sleep were tested using a 4 (rank) x 2 (sex) x time factorial analysis of variance. Significant differences among ranks were followed up using a Tukey post-hoc test. Homogeneity between the groups was tested (Mauchly’s Test of Sphericity) and the appropriate within-subject test used. Required sample size was calculated as 232 samples based upon 95% effect size for a 4 x 2 factorial analysis of variance. Alpha was set at $p<0.05$.

RESULTS

During the working day dancers spent 480.3 ±12.83 minutes above 1.5 METs. As the intensity of activity increased the time spent within these categories decreased with the majority of time at low intensities (271.9 ±71.7 min), moderate intensity accounted for 173.5 ±56.2 min and vigorous and very vigorous just 28.4 ±23.3 min and 6.5 ±9.08 min, respectively. A similar patter was observed for extra-activities outside of the working day (total time above 1.5 METs 436.1 ±86.26 min); low intensity 436.1 ±86.26 min, moderate 104.4 ±51.64 min, vigorous 10.2 ±11.26 min and very vigorous 2.5 ±4.48 min. Sleep for all participants ranged between 158-578 minutes a night (396.7 ±71.59 min).

Main activity results

The main activities of total physical activity, working day physical activity (WD-PA), extra-curricular physical activity (Extra-PA) and sleep were analysed. Significant main effects were observed for rank ($F_{12,645}$=3.241, $p<0.001$) and rank by sex ($F_{12,645}$=4.339, $p=0.003$) but not sex alone (Table 2). A number of variables reported significant between subject effects; working day PA reported a significant difference for rank by sex ($F3_{,216}$=2.851, $p=0.038$) with female dancers, particularly principals recording longer working hours. Sleep had significant rank by sex differences ($F_{3,216}$=4.430, $p=0.005$) and ranged between 2.4-9.6 hours per night, with Artist ranks, especially females, recording the most sleep ($p=0.028$). Both Total-PA and Extra-PA reported between subject effects for rank by sex ($F_{3,216}$=3.706, $p=0.012$ and $F_{3,216}$=2.851, $p=0.038$, respectively). Dancers engaged in extra PA ranging from between 1 hour to 12 hours with a mean engagement of 9 hours a day (>1.5 METS).

Table 2. Time spent in different activities during 24-hrs

Rank	Sex	Days	Total PA (min)	WD-PA (min)	Extra-PA (min)	Sleep (min)
Principal	Male	19	1032.4 ±103.2	479.1 ±3.9	551.3 ±101.1	409.6 ±101.1
	Female	14	1038.6 ±43.5	493.9 ±5.9	556.7 ±86.9	389.4 ±60.5
Soloist	Male	28	1040.6 ±87.7	479.5 ±2.6	568.5 ±81.9	392.0 ±82.2
	Female	35	1043.7 ±63.2	480.0 ±70.4	562.8 ±67.5	397.2 ±67.5
First Artist	Male	45	1031.8 ±73.9	479.5 ±2.7	565.1 ±62.8	390.4 ±55.7
	Female	18	1084.6 ±92.7	478.4 ±6.6	563.9 ±114.6	367.2 ±84.9
Artist	Male	41	1035.0 ±73.6	479.2 ±4.8	550.6 ±64.3	395.1 ±67.8
	Female	24	982.3 ±49.9	480.0 ±0.2	509.4 ±80.4	451.5 ±52.7

Working-day activity

The analysis of the different METS bands during the working-day revealed a significant main effect for rank ($F_{21, 636}$ = 2.473; $p=0.007$) and a significant interaction effect between rank and sex ($F_{21, 636}$ = 3.091; $p < 0.001$).

Table 3. Time spent in activity bands during the working day.

Rank	Sex	Low (min)	Moderate (min)	Vigorous (min)	Very Vigorous (min)
Principal	Male	279 ± 84.06	160 ± 61.10	31 ± 21.26	9 ± 8.1
	Female	232 ± 94.83	199 ± 52.52	52 ± 31.85	10 ± 10.92
	Total	260 ± 90.34	176 ± 60.12	40 ± 27.81	10 ± 9.23
Soloist	Male	282 ± 73.34	168 ± 62.86	21 ± 14.76	9 ± 12.32
	Female	272 ± 76.35	166 ± 56.39	35 ± 34.60	8 ± 13.59
	Total	276 ± 74.67	167 ± 58.77	29 ± 28.65	8 ± 12.98
First Artist	Male	292 ± 66.36	161 ± 54.41	23 ± 18.00	4 ± 5.46
	Female	260 ± 52.27	185 ± 39.93	28 ± 19.42	5 ± 6.28
	Total	283 ± 64.07	168 ± 51.72	24 ± 18.39	4 ± 5.67
Artist	Male	238 ± 55.49	202 ± 48.12	33 ± 19.54	6 ± 6.17
	Female	301 ± 62.00	156 ± 54.46	17 ± 11.72	5 ± 7.44
	Total	265 ± 65.82	183 ± 55.49	27 ± 18.40	6 ± 6.68
Total	Male	274 ± 67.89	173 ± 56.71	26 ± 17.28	6 ± 8.18
	Female	274 ± 74.53	171 ± 55.21	30 ± 25.07	7 ± 10.67

Between-subject effects found significant differences within ranks for time spent at vigorous ($F_{3,237}$= 4.629; p=0.004) and very vigorous intensity ($F_{3,237}$= 2.881; p=0.037) (Figure 1). Post-hoc analysis revealed Principals spent significantly more time at vigorous intensity than Artists, First Artists, and Soloists (p<0.05) and at very vigorous with First Artists (p<0.05). Additionally, between-subjects effects found a significant difference between sexes for time spent at vigorous intensity ($F_{1,237}$ = 4.140; p=0.043), with females spending significantly more time than males during the working day. Moreover, time spent in the low intensity band was greater than time in all physical activity bands combined.

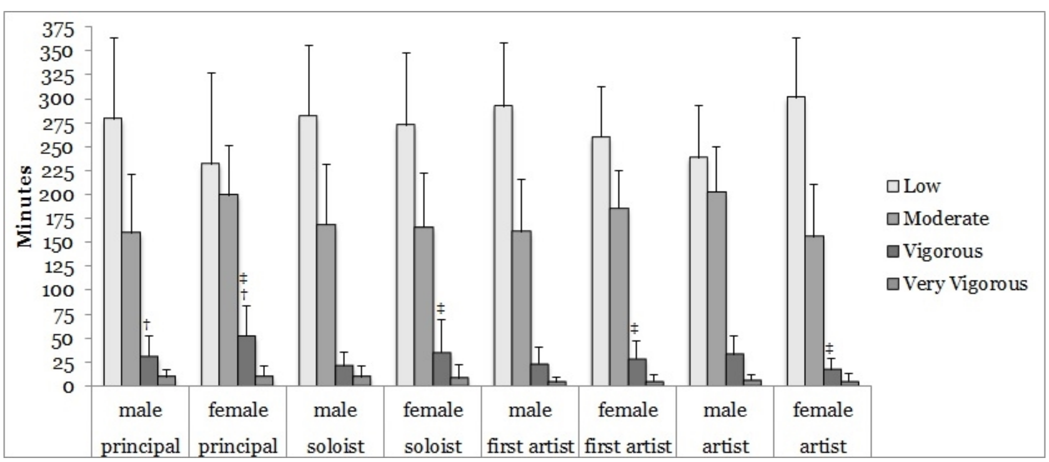

Figure 1. Working-day MET profile for the different ranks.

Between-subject interaction effects showed significant differences for time spent at low (p< 0.01], moderate (p<0.01], and vigorous intensities (p<0.01] (Table 3.) Figure 2 demonstrates female Principals spent less time in the low band and more time in the moderate and vigorous bands than their male peers, while female Artists spent more time at low intensity and less time at moderate and vigorous intensities than male Artists.

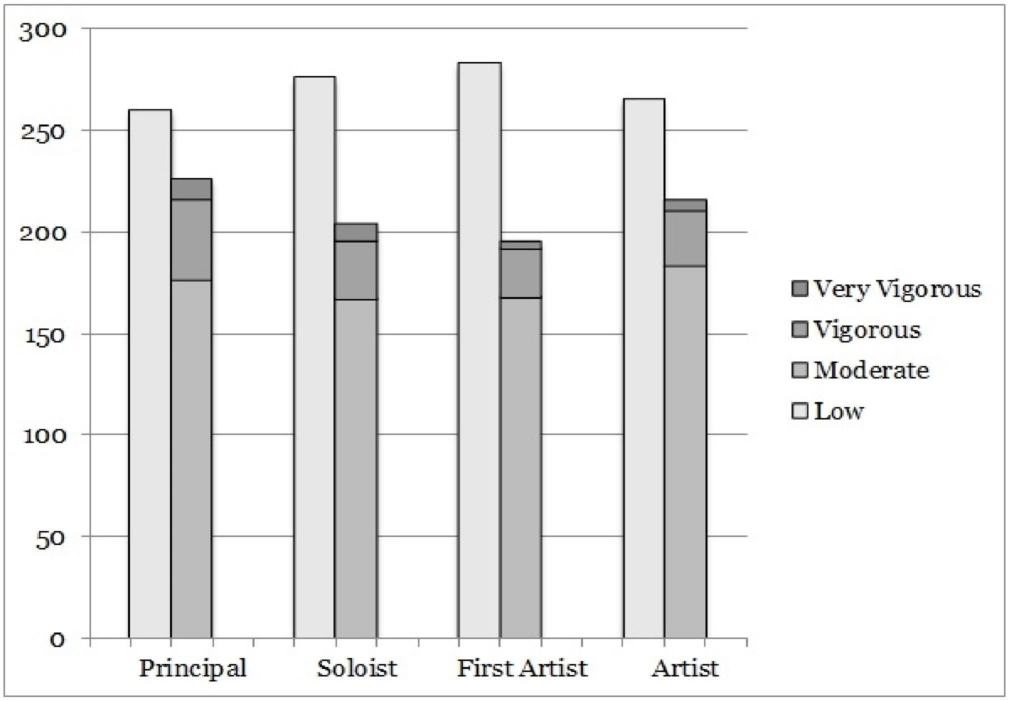

Figure 2. Time in low intensity band versus combined physical activity bands during the working day

Within Working Day Rest

The mean Greatest Rest Break during the working day was 35 ±26.86 minutes (range 10-153 minutes) with a between-subject effect for sex ($F_{1,234}$=4.007; p=0.046). Females had significantly shorter GRB than males (32 ±27.94 vs. 38 ±24.97 minutes). The other accumulated breaks during the day (MRB) reported a between-subjects effect for rank ($F_{3,234}$=3.054; p=0.029) and sex ($F_{1,234}$=11.218; p=0.001). Accumulated rest (GRB+MRB) throughout the day reported a between-subjects effect for sex ($F_{1,234}$=5.167; p=0.024) with females having less rest than males (38 ±28.73 vs. 46 ±31.04 minutes).

Physical Activity Outside Working Hours

Multivariate statistics reported a main effect for rank ($F_{12,654}$=2.368; p=0.005) and rank by sex ($F_{12,654}$=2.115; p=0.014) (Table 4). Between subject effects reported significant differences in rank for low intensity activity ($F_{3,219}$=6.931; p<=0.001) with Artists spending significantly less time at in this band than Soloists (p=0.01) and First Artists (p=0.003).

Table 4. Time spent in activity bands outside of the working day.

Rank	Sex	Low (min)	Moderate (min)	Vigorous (min)	Very Vigorous (min)
Principal	Male	449 ± 76.69	92 ± 53.36	8 ± 7.43	2 ± 2.48
	Female	373 ± 127.74	127 ± 54.40	16 ± 13.59	3 ± 3.64
	Total	415 ± 107.67	108 ± 50.98	12 ± 11.08	2 ±3.06
Soloist	Male	454 ± 75.77	100 ± 46.82	10 ± 11.44	4 ± 6.58
	Female	453 ± 83.67	96 ± 53.42	8 ± 9.56	3 ± 4.97
	Total	454 ± 79.62	98 ± 50.24	8 ± 12.53	4 ± 5.72
First Artist	Male	450 ± 80.87	99 ± 60.30	8 ± 9.56	2 ± 4.57
	Female	479 ± 102.86	94 ± 32.53	10 ± 9.99	2 ± 2.16
	Total	458 ± 87.74	98 ± 53.75	9 ± 9.63	2 ± 4.02
Artist	Male	413 ± 60.40	125 ± 46.78	15 ± 11.27	3 ± 4.76
	Female	397 ± 79.75	100 ± 51.66	6 ± 9.75	1 ± 0.62
	Total	407 ± 67.92	116 ± 49.84	12 ± 11.61	2 ± 4.09
Total	Male	439 ± 74.65	106 ± 52.46	11 ± 10.61	3 ± 4.94
	Female	430 ± 101.14	101 ± 50.31	10 ± 12.24	2 ± 3.69

A between-subject effect was as reported for sex by sex for low ($F_{3,219}$=2.828; p<=0.039), moderate ($F_{3,219}$=2.646; p<=0.05) and vigorous ($F_{3,219}$=4.901; p<=0.003); female Principals spent less time in the low band, while female Principals and male artists spent more time at moderate and vigorous intensities.

Comparison of the time spent in the different MET bands between the working day (WD-PA) and the rest of the day (Extra-PA) reported main effects for rank ($F_{12,657}$=2.197, p=0.011) and rank by sex ($F_{12,657}$=2.675, p=0.001). All ranks spent more time between 1.5-3 METS outside of work (p=0.009) (Fig 3), though there were no significant time differences for sex or rank at 3-6 METS. Working day time spent in the vigorous (6-9 METS) were significantly greater for sex (p=0.01) and rank (p=0.002) than the rest of the day.

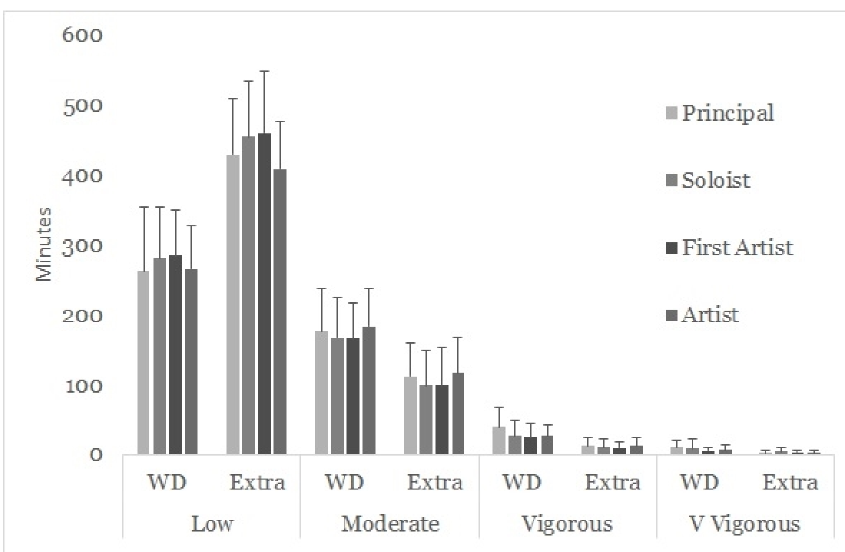

Figure 3. Time spent in physical activity MET bands during the working day versus extra physical activity for the different ranks.

DISCUSSION

The monitoring and manipulation of training load has been shown to improve performance and reduce injury incidence in sport[24]; within dance, fatigue and overwork have been cited as the main self-reported causes of injury[1]. Therefore, controlling the dancers' training load could potentially reduce the impact of these variables. The data from the current study has highlighted some issues that need to be considered. Firstly, professional ballet dancers engaged in more physical activity outside of their work day than during it. Secondly, during the working day female dancers, in particular principals, had longer working days than their male counterparts. Thirdly, males had longer total rest time than females during the day and this was also mimicked for the mid-day break (GRB). Finally, sleep time ranged between 3-9 hours with only 16% achieving 8-hours a night; the lower ranks (Artists) recorded the longest periods.

Workload Intensity Profiles

Although the dancers in this study were considered "working" for 8 hours each day, on average they spent more than 50% of this time between 1.5- 3 METS. This was true for all subgroups of rank and sex with the exceptions of female Principals and male Artists and was consistent for 75% of the total working days collected. The time spent engaging in physical activity was predominately at moderate intensity (mean 173 minutes per working day), with the remainder spent at vigorous and very vigorous intensities (mean 28 and 6 minutes per working day, respectively). This profile reinforces the description of dance as an intermittent activity [6, 8, 25], but suggests that within a rehearsal context, moderate intensities make up the bulk of the physical activity.

Significant differences existed amongst ranks for working-day intensities, with more senior dancers demonstrating higher workloads. Principal dancers spent significantly more minutes at vigorous intensities than all other ranks. By comparison, Twitchett and colleagues [14] found Soloists demonstrated a higher workload than dancers of other ranks, but emphasized the Soloists were cast in Principal roles in addition to their Soloist obligations.

Within ranks, sex played a significant moderating role on the amount of time spent at low, moderate, and vigorous intensities. While female Principals demonstrated a higher-intensity workload than male Principals, the opposite was true for Artists. Thus, as female dancers moved up the ranks they could expect their workload intensities to increase, while males could expect a decreased physical activity requirement. It is unclear whether this result was indicative of an inherent aspect of daily life in a professional ballet company or impacted by casting. It could be broadly stated that one of the main roles of a male principal dancer is to support the female dancer in their virtuosity roles, and the more active roles for males are carried out by soloists; though this will vary according to the ballet and the company.

Physical Activity Outside Working Hours

Dancers in the present study participated in a significant amount of added physical activity outside working hours: on average the dancers completed 103 min/day at moderate intensity, 9 min/day at vigorous intensity, and 2 min/day at very vigorous intensity. This was a surprising finding for two reasons; firstly, dancers had been active (at various intensities) for 8 hours during their work day and then to do approximately two hours "extra" each day is a significant addition to the stress placed on their bodies. Secondly, dancers report feeling fatigued and overworked[1] but engage in extra activity, that is under their control, that could be curtailed to prevent those feelings. Interaction effects followed the same trend as the workloads seen during scheduled working hours, with female principals and male artists showing the highest amounts of added physical activity outside work. It could be that female dancers perceive there is more competition for the higher ranks than experienced by male dancers and therefore engage in more extra-training to help their promotion. Further research is needed to explore what are these activities and the motivation for extra activity. This adds credence to the conclusion that activity profiles for professional dancers are highly individualized and dependent on sex and rank.

Rest Breaks

Despite spending most of working hours at a low intensity, the dancers in this study did not spend a substantial amount of continuous time at lower than 1.5 METS. There was a sex difference with male dancers taking significantly longer continuous rest breaks than females. Union contracts within the UK stipulate that dancers be given a 60-minute lunch-break but within this cohort only 35% of recorded days achieved this, comparable to previous data [14]. While appropriate breaks were timetabled administratively, these results indicate very few dancers took this time to sit and rest. This influences sufficient time to consume and digest adequate nutrition and could have a negative impact on energy balance[26]. The catering provision we see in professional sports clubs and the nutrition education given to athletes is often lacking even in big professional dance companies and highlights the different priorities between sport and dance where the former tries to influence any factor that could potentially affect performance.

Sleep

Recommended levels of sleep range from 5 to 10 hours, but athletes are generally considered to require more sleep to cope with the physical, cognitive, and immunosuppressive effects of exercise[19]. The dancers in this study averaged 6:40 hours of sleep per 24 hours (2:38-9:38 hours), with 9.5% of sleep periods below 5 hours and only 16% achieving 8 hours a night. Previous research on Olympic-level athletes demonstrated approximately 7 hours of sleep each night with worse sleep efficiency than non-athletic controls[27]. Fietze and colleagues[20] found total sleep and sleep efficiency declined from 7 to 6.5 hours a night as professional ballet dancers approached the premier of a new work. Their health and cognitive markers similarly declined, indicating the dancers were not at their physiological or psychological peak prior to performance[20].

Sleep deprivation has demonstrable effects upon submaximal performance, cognitive and motor learning ability, and mood state[19, 20]. There is also some evidence chronic sleep deprivation may be related to the onset/amplification of pain[28], and muscle repair and growth can be limited due to reductions in insulin-like growth factor 1 in sleep-deprived states[29-32]. The high-skill nature of ballet indicates sleep deprivation may have implications on motor learning and performance capabilities; rehearsing in sleep-deprived states may place the dancers at increased risk of injury due to inadequately recovered muscles and decreased cognitive functioning.

Fatigue and overwork have been reported as the main causes of injury within the dance profession[1]. The data from the current study highlights the need for a global view of the dancers' lifestyles when ascertaining possible causes of injury as the amount and intensity of physical activity outside of the work environment is rarely considered as an influencing factor. Sleep patterns are often disruptive within professional dance. It can resemble shift work with periods of day shifts (class and rehearsals) followed by late evening shifts (rehearsals and performances); this pattern has been shown to affect sleep quality and health[33]. This effect could be exaggerated within dance due to the "high" felt after a performance, resulting in an increased time period before the mind and body are ready for optimal sleep.

Although this is the first study that has provided comprehensive data on workload intensities and sleep quantity of professional ballet dancers, the lack of physical activity diaries and injury incidence limits the conclusions that can be drawn. In the present cohort it seems as though age is related to rank, with older dancers being soloists or principals. Analysis of all the dancers in the two companies the current cohort came from indicated that age isn't related to rank. The accelerometers used in the present study were relatively bulky and needed to be removed during ablutions and could account for the amount of lost data; other slimmer waterproof accelerometers might provide more consistent data collection but we hadn't validated them for dance.
The data from the present study highlights areas of concern: firstly, the company should enforce the necessary breaks by making sure that class or rehearsals do not over run into break periods; secondly, through education, dancers should take personal responsibility to optimize recovery and sleep time and reflect on extracurricular activities and how these could be affecting perceptions of fatigue and overwork. Recent research has suggested

training at the same time of day as performances might be an option[34], though this would require a major review of current schedules and union contracts. The data on these benefits are limited, but ballet companies can have between 120-180 evening dance performances a year.

In conclusion, when looking at potential causes of injury in dance, a global perspective of physical activity is required that includes activity outside of work and sleep patterns, all activities that influence physiological recovery. In the current cohort, significant amounts of exercise where carried out outside of their work day, therefore when injury is reported per 1000 hours dance activity[35], this extra-curricular activity might need to be included. Poor sleep practices, only 16% achieving 8 hours a night, could also be another factor that limits recovery and increases injury risk.

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